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Webinar: Contextual Guidance at Intersections for Protected Bicycle Lanes

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Contextual Guidance at Intersections for Protected Bicycle Lanes

NITC Webinar

October 8, 2019

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Portland State UNIVERSITY

TOOLE DESIGN

NITC NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

Today's Outline

- Background and research approach
- Development of survey
- Survey results
- Simulation modeling
- Contextual guidance
- Conclusions

Note on Final Report

- Currently addressing the last of the technical review panel's peer-review comments.
- Report to published by NITC very soon.
- Some minor changes to material presented here are possible.

Key Take Aways

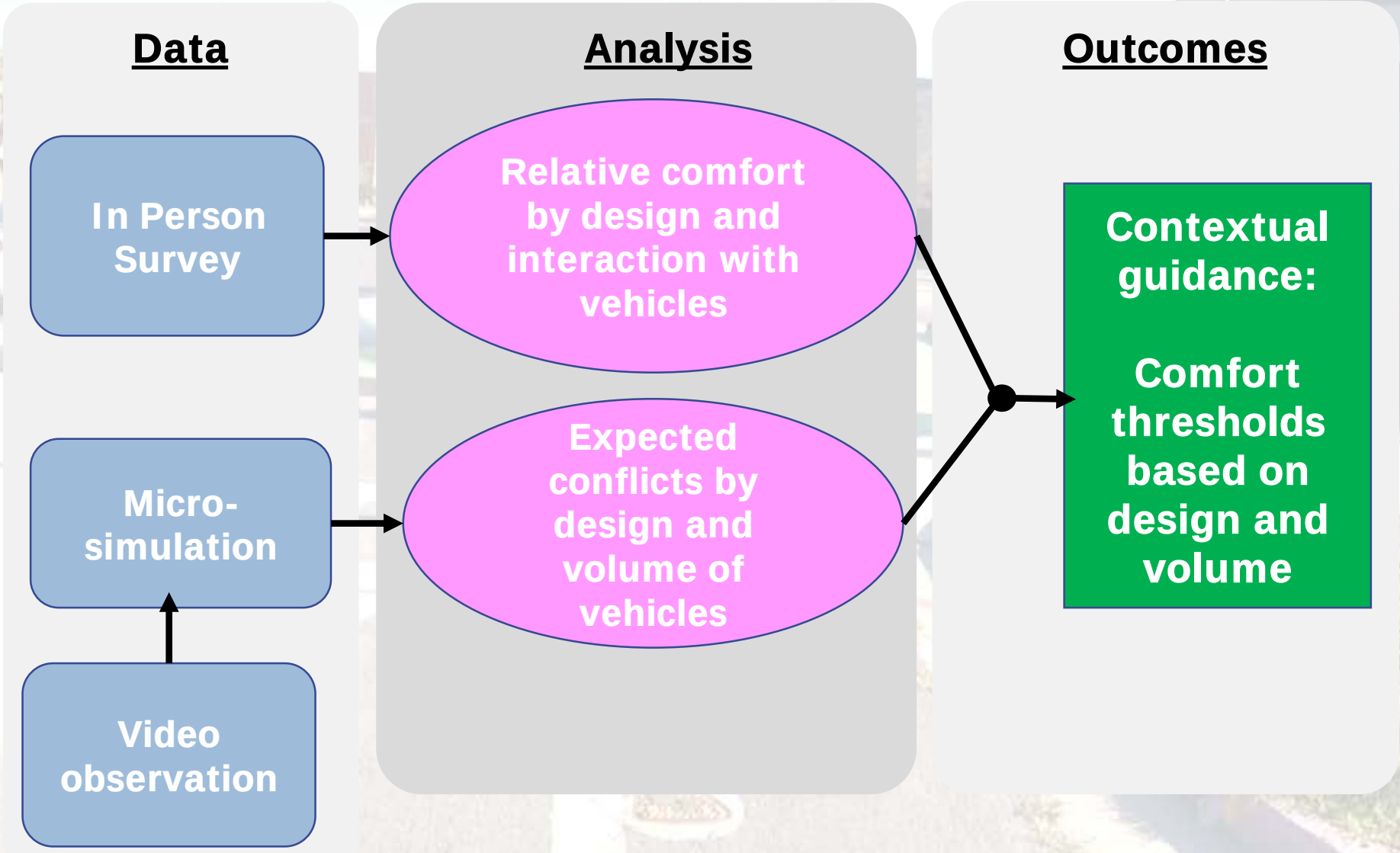
- Research developed estimates of perceived comfort of typical intersection designs.
- Separation (in time or space) and distance exposed to traffic are key drivers of comfort.
- Bend out / offset / protected and fully signalized designs provide most comfort to the most people.
- Actual safety of designs not addressed by this research.
  - *Recent NY DOT "Cycling at Crossroads" provides good information*

Background and Research Approach

Protected Bike Lanes

- Protected/separated bike lanes are preferred by cyclists and potential cyclists *(Sanders, 2016; McNeil et al. 2015; Dill and McNeil 2016).*
- In general, protected/separated bike lanes are associated with increased safety *(Marshall and Ferenchak 2019; Harris et al. 2013; Teschke et al., 2012; Lusk et al. 2013).*
- Intersections are the weak link:
  - Safety (in terms of reported crashes and observed conflicts) is an essential consideration.
  - Perceived comfort is also a key consideration for cities attempting to build connected low-stress networks, given the link between perceived comfort and ridership

Research Overview

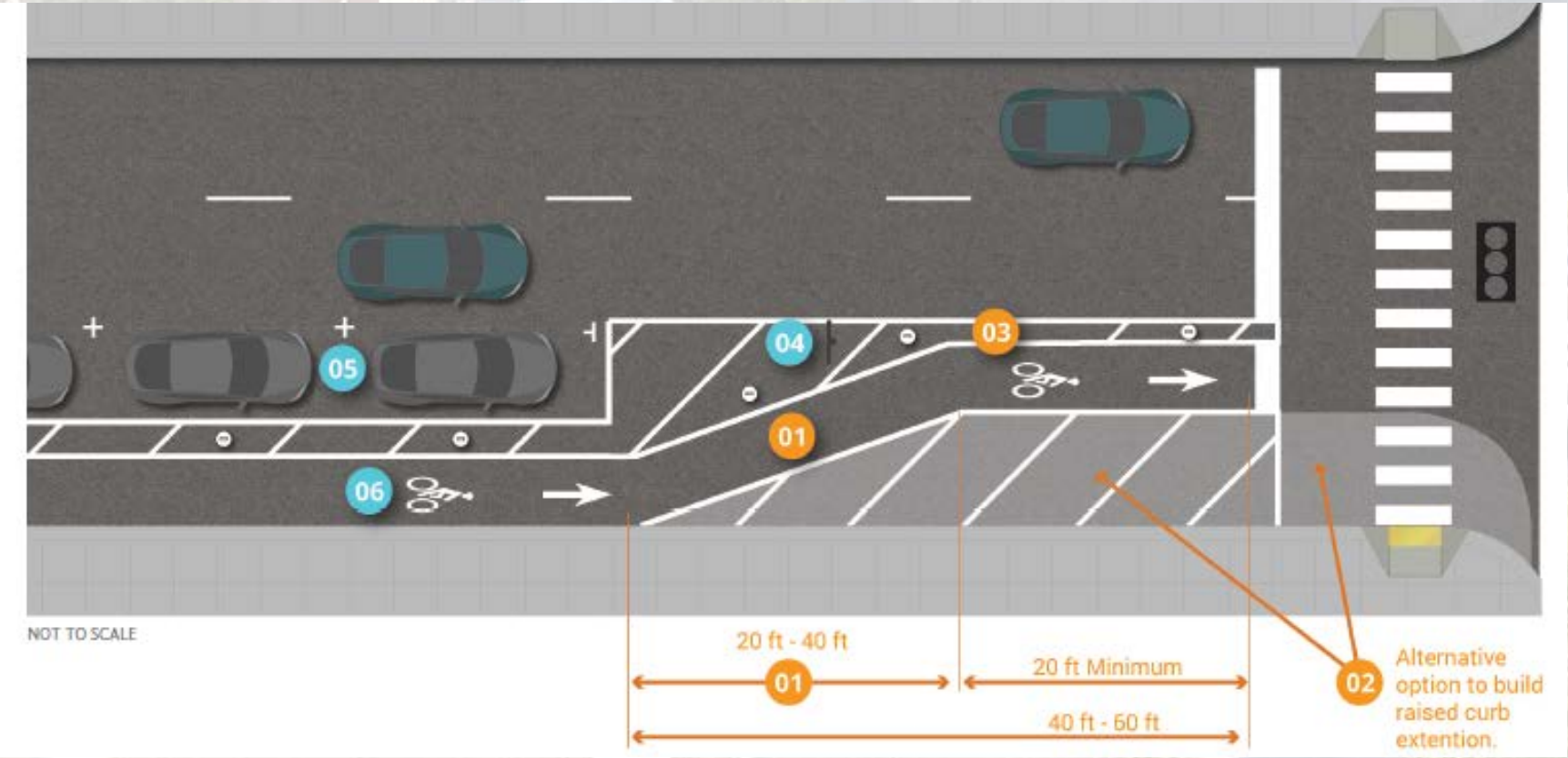


Scope

- One-way configurations
- Focus on the right-turning interaction
- Designs evaluated
  - Maintain separation
    - No Bend
    - Bend In
    - Bend Out (Protected Intersection)
    - Bike Signal
  - Mix bicycles and vehicles
    - Mixing Zones
    - Lateral Shift

Design Option: Bend-in

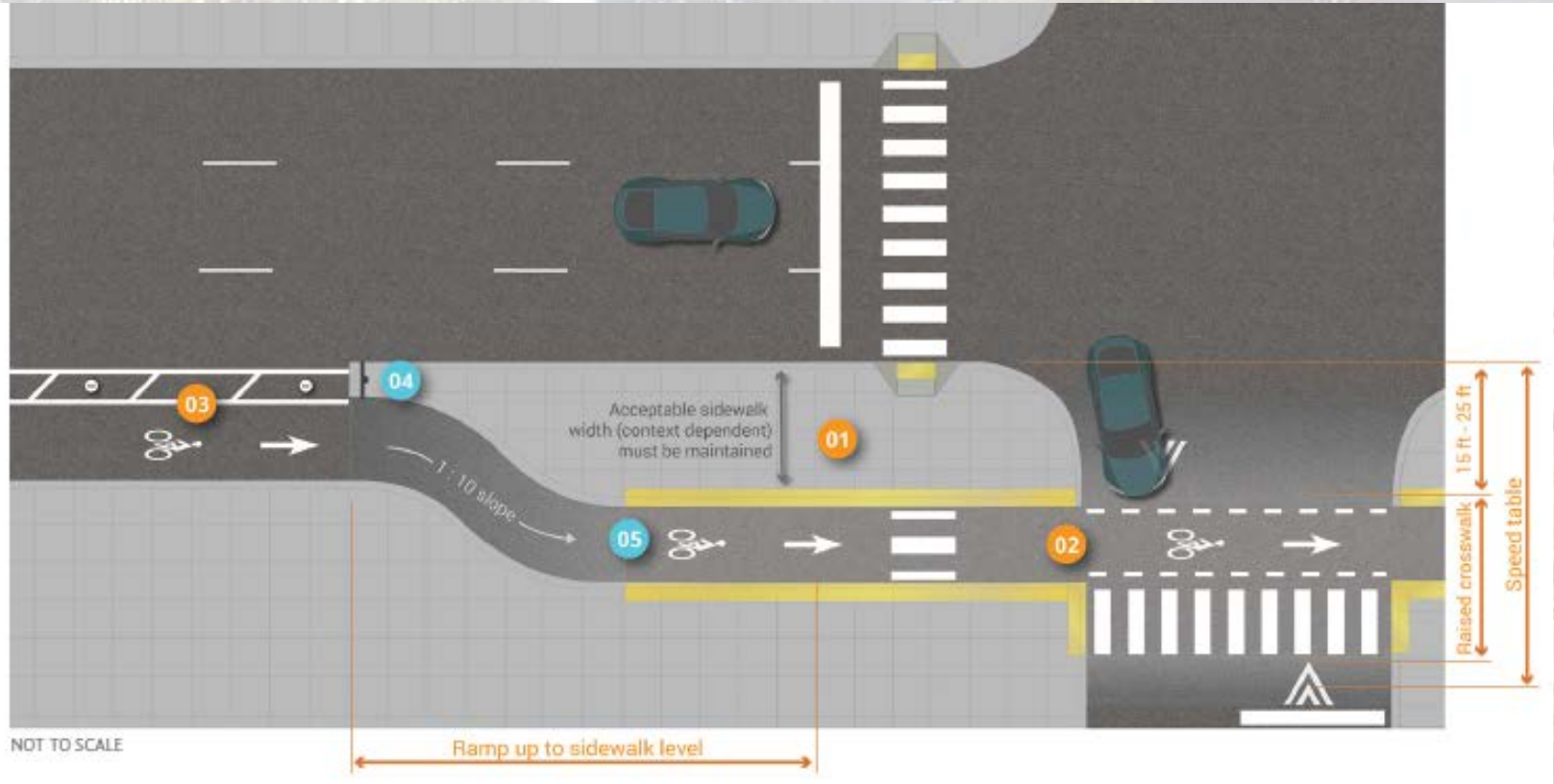
Shifts the bike lane in toward the motor vehicle lanes, which can increase visibility and awareness of bicyclists and motorists of one another.



Source: Fig. 25. FHWA Separated Bike Lane Planning and Design Guide (2015), page 108

Design Option: Bend-out

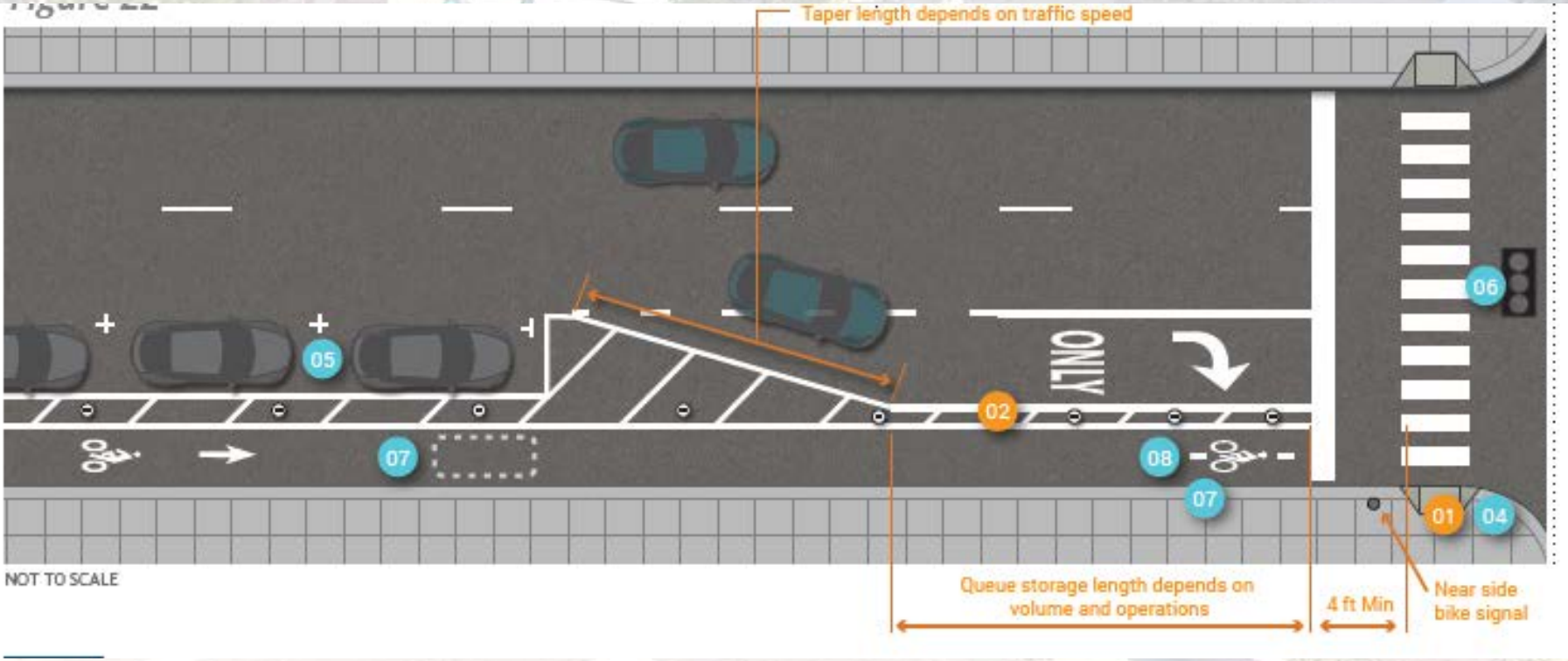
Shifts the bike lane away from the motor vehicle traffic, which results in turning motorists having exited the through travel lane prior to crossing the bike lane, slowing their speed and approaching the crossing at closer to a 90 degree angle.



Source: Fig. 26/ FHWA Separated Bike Lane Planning and Design Guide (2015), page 109

Design Option: Bike Signal

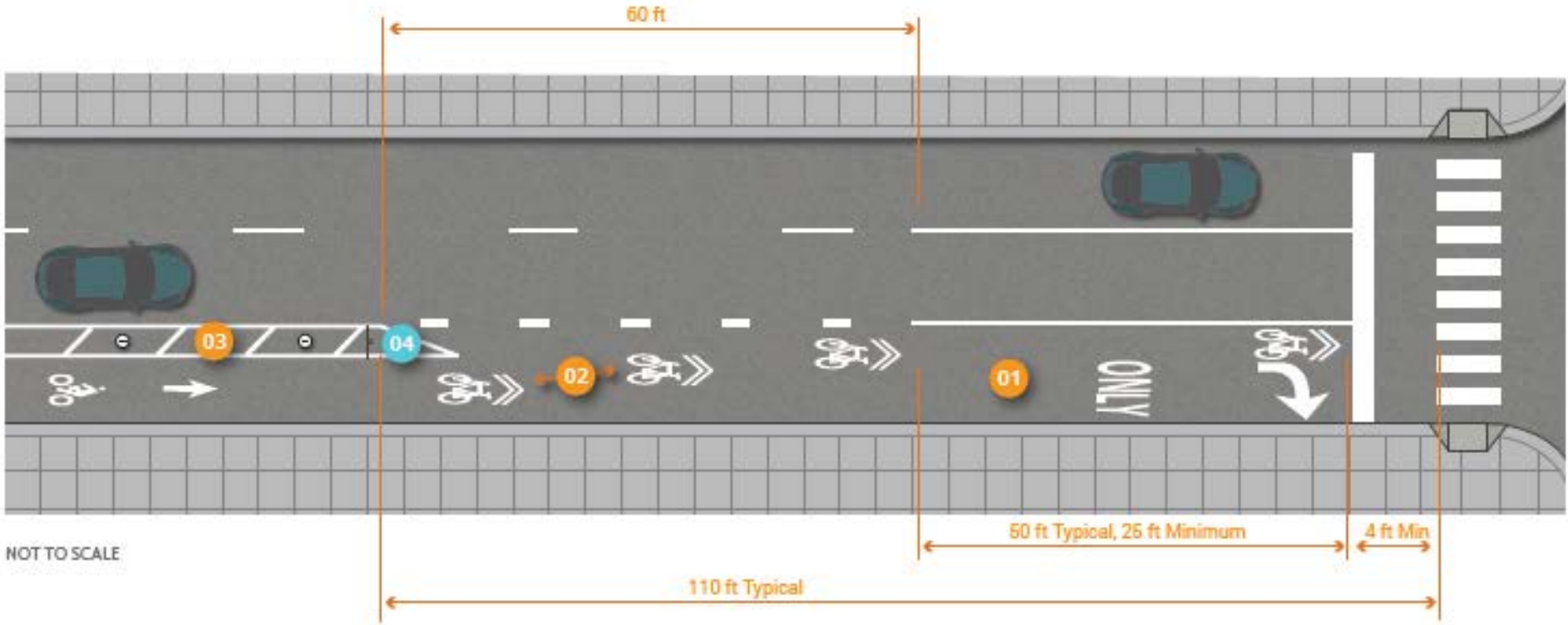
Motor vehicle traffic and bicycle traffic have separate traffic signals that separate out their movements in time.



Source: Fig. 22. FHWA Separated Bike Lane Planning and Design Guide (2015), page 109

Design Option: Mixing Zone

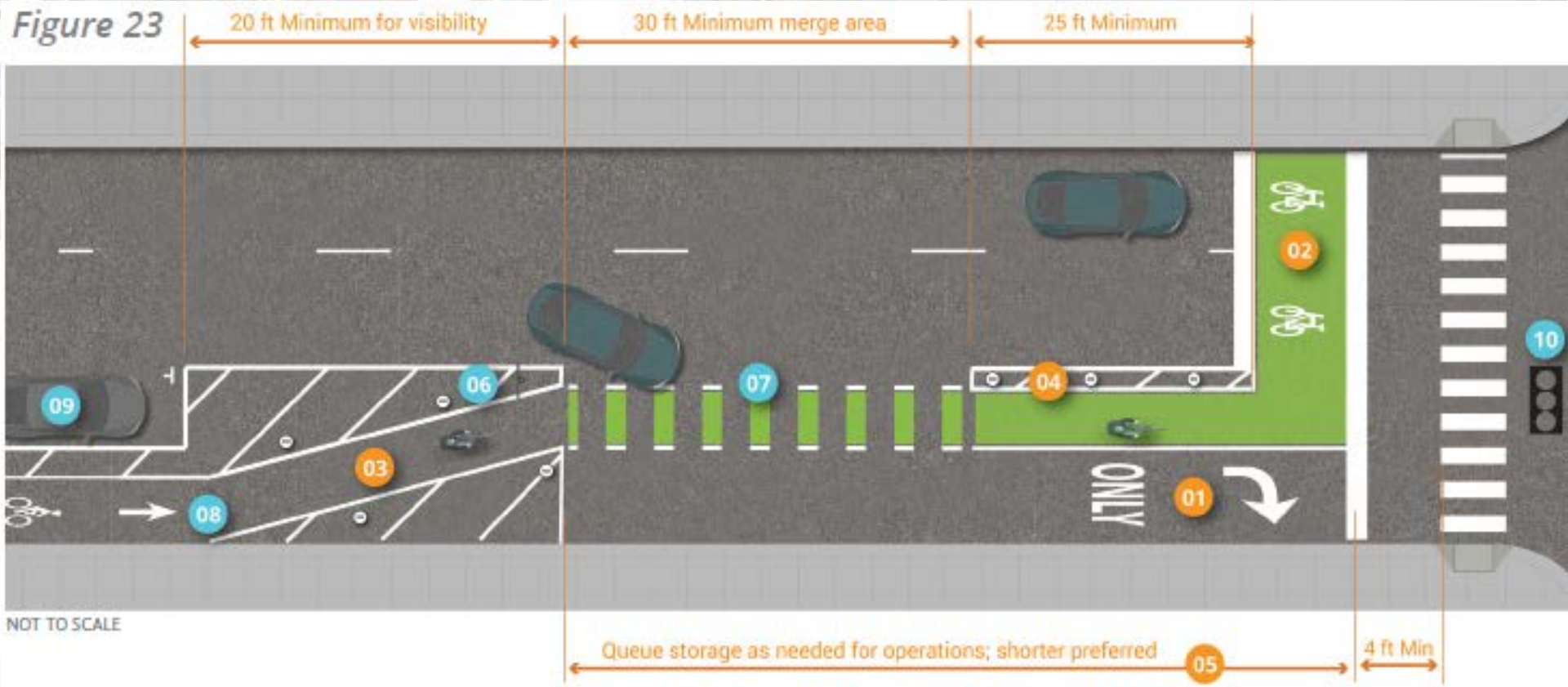
Establishes a right turn lane and ends the bike lane, creating a mixing area for bicyclists and turning motorists.



Source: Fig. 24. FHWA Separated Bike Lane Planning and Design Guide (2015), page 107

Design Option: Lateral Shift

Moves the bicyclist in and provides a crossing area for turning motorists to shift into a turn lane, with their paths crossing before the bike lane is reestablished to the inside of the turn lane.



Source: Fig. 23. FHWA Separated Bike Lane Planning and Design Guide (2015), page 105

Development of Survey Instrument

Collecting and Curating Sample Clips

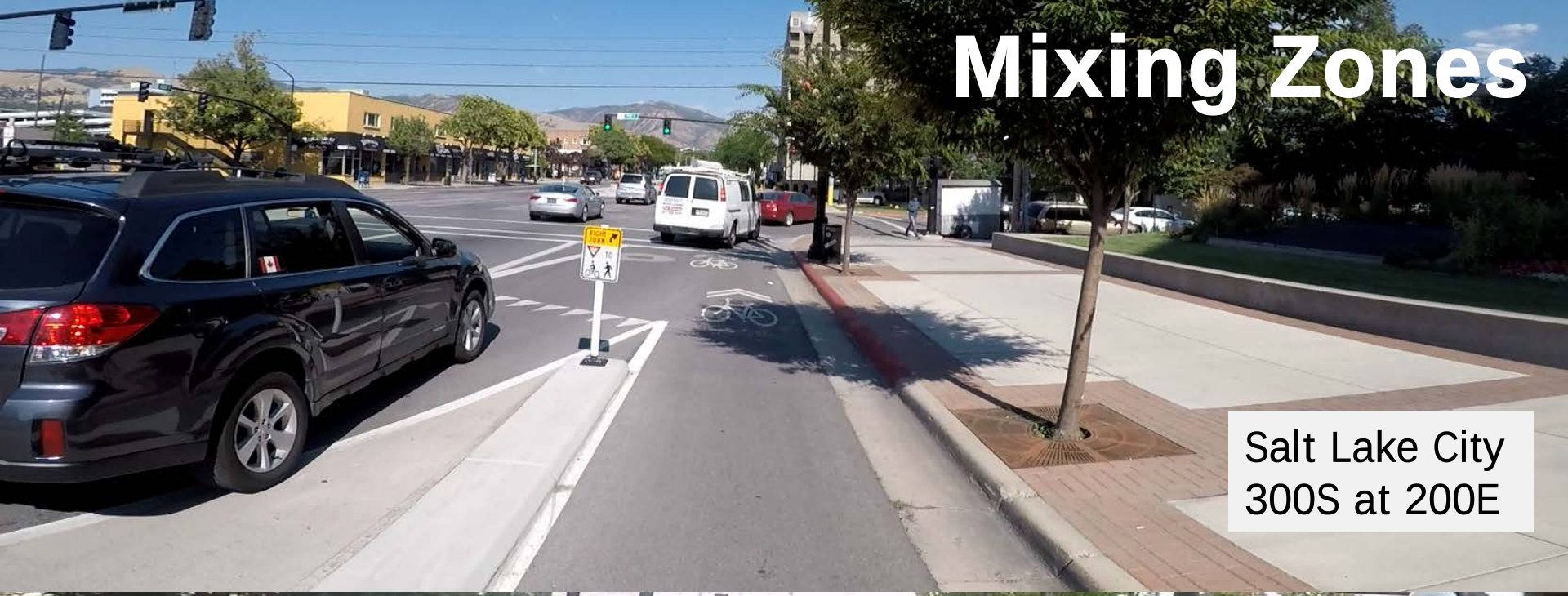
10 locations from:

- Denver, CO
- Portland, OR
- Salt Lake City, UT
- Seattle, WA

Location	City	Design Type	Bend (ft.)	Mix / merge (ft.)	Exposure distance[1] (ft.)
Arapahoe at 18th	Denver, CO	Bike signal	-	-	78
200W at 300S	Salt Lake City, UT	Bend-out / protected intersection	+ 12	-	15 + 25[2]
14th at Delaware	Denver, CO	Bend-in	- 8	-	65
300S at 300E	Salt Lake City, UT	Bend-in	- 12	45	199
Lawrence at 19th	Denver, CO	Lateral shift	- 15	110	190
Roosevelt at 50th	Seattle, WA	Lateral shift	- 10	55	140
NE Multnomah at 11th	Portland, OR	No Bend	-	-	54
NE Multnomah at 9th	Portland, OR	Mixing zone	-	95	162
300S at 200E	Salt Lake City, UT	Mixing zone	-	30	145
Dexter at Harrison	Seattle, WA	Mixing zone	-	40	102

[1] The protected intersection location crossing had a median, thus breaking the crossing distance into two sections of 15 feet and then 25 feet.

Mixing Zones



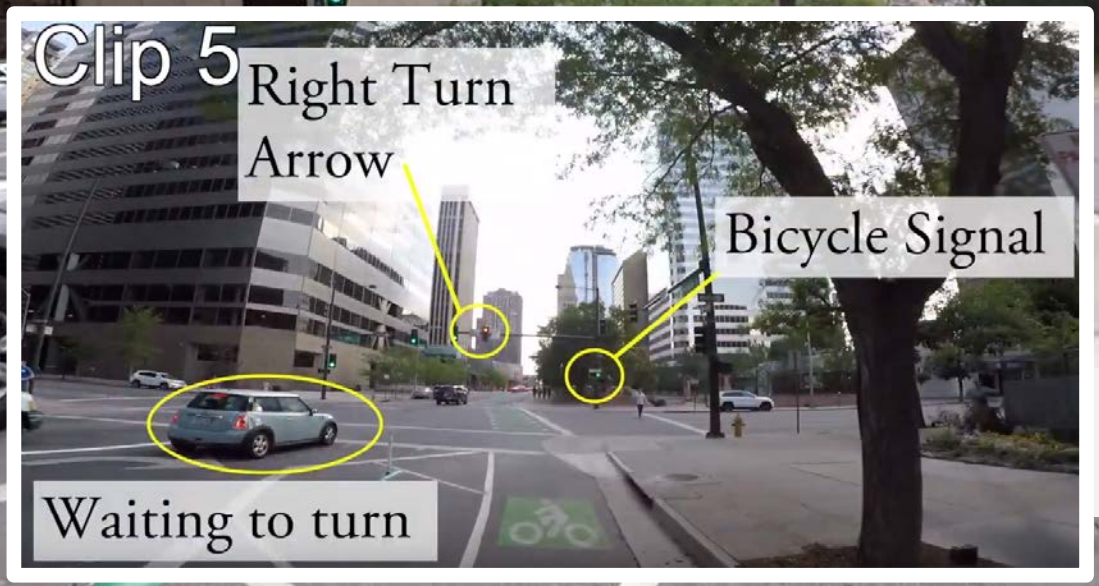
Salt Lake City
300S at 200E

Portland
NE Multnomah

Mixing Zone

Seattle
Dexter at Harrison

Bicycle Signal



Denver
Arapahoe at 18th

Lateral Shift

Denver
Lawrence and 19th

Seattle
Roosevelt NE at 50th

Bend In

Salt Lake City
300S at 300E EB

Denver
W 14th Ave at Delaware

Bend Out / Protected Intersection

Salt Lake City
200W at 300S

No Bend

Portland
Multnomah and 11th

Controls:
Off Street Path

Springwater Corridor Trail,
Portland, OR
Avg. Rating = 4.77

Protected Bike Lane Segment

NE Multnomah Protected Lane,
Portland, OR
Avg. Rating = 4.54

Example clip - Interaction

https://youtu.be/VrFGqoBrgaA

Example clip – Turn Visible

https://youtu.be/ONUwFDADf-Y

In Person Survey

*Each clip will be shown twice, after which you will rate it based on how comfortable you would feel riding a bicycle in that situation. The rating scale is:

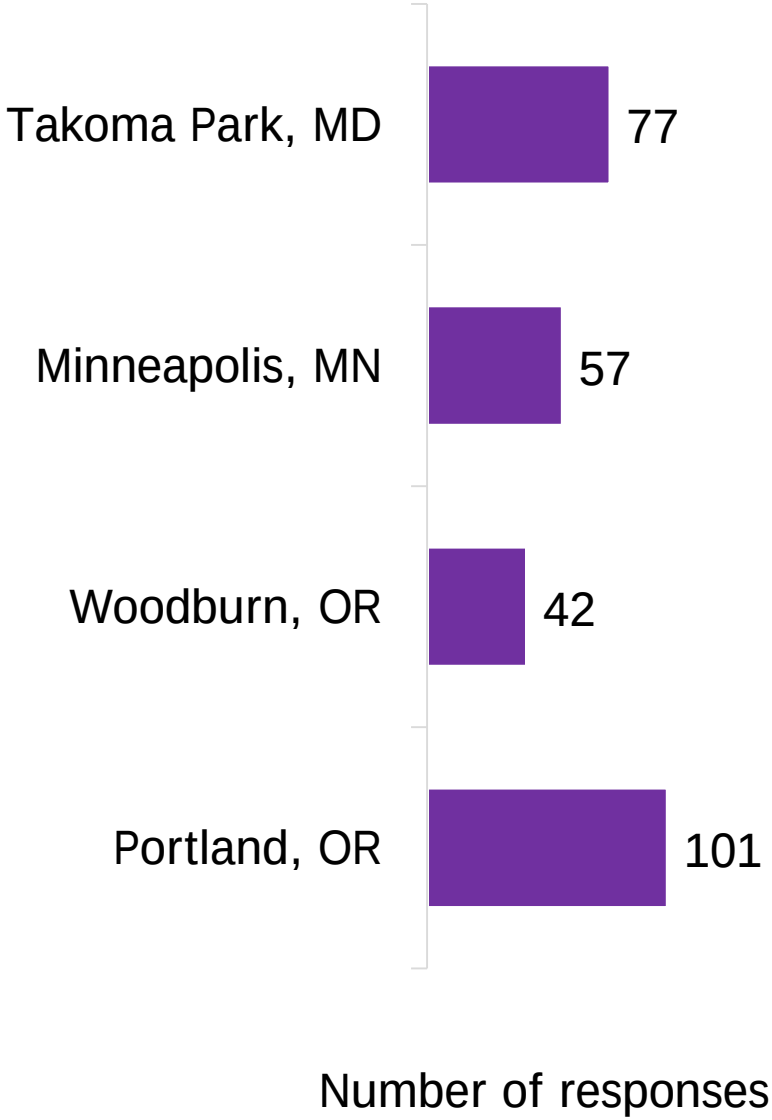
1	2	3	4	5
Very Uncomfortable	*Somewhat Uncomfortable*	*Neither Uncomfortable nor Comfortable*	*Somewhat Comfortable*	*Very Comfortable*

**Several clips will be a shown a third time, when you'll be asked to indicate if you would consider riding a bike in that situation with a 10-year old child (on their own bike).

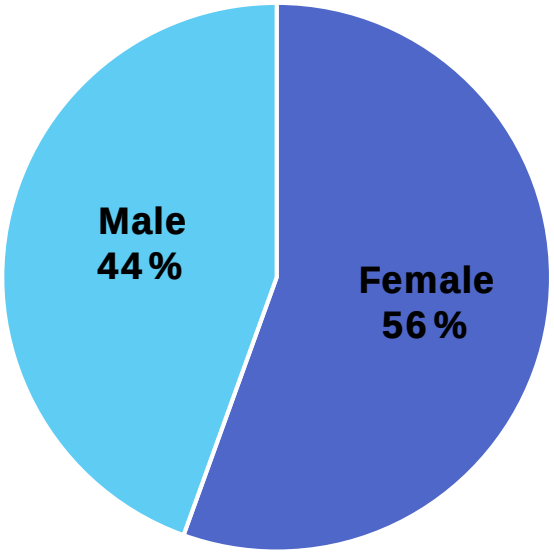
Clip #	Comfort Rating (Very Uncomfortable 1 - 2 - 3 - 4 - 5 Very Comfortable)	Ride with child?
1	1 - 2 - 3 - 4 - 5	
2	1 - 2 - 3 - 4 - 5	
3	1 - 2 - 3 - 4 - 5	Y / N
4	1 - 2 - 3 - 4 - 5	Y / N
5	1 - 2 - 3 - 4 - 5	
6	1 - 2 - 3 - 4 - 5	

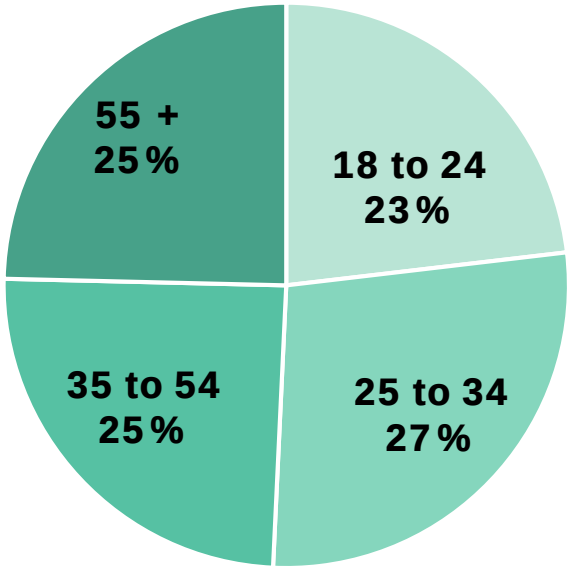
In Person Survey

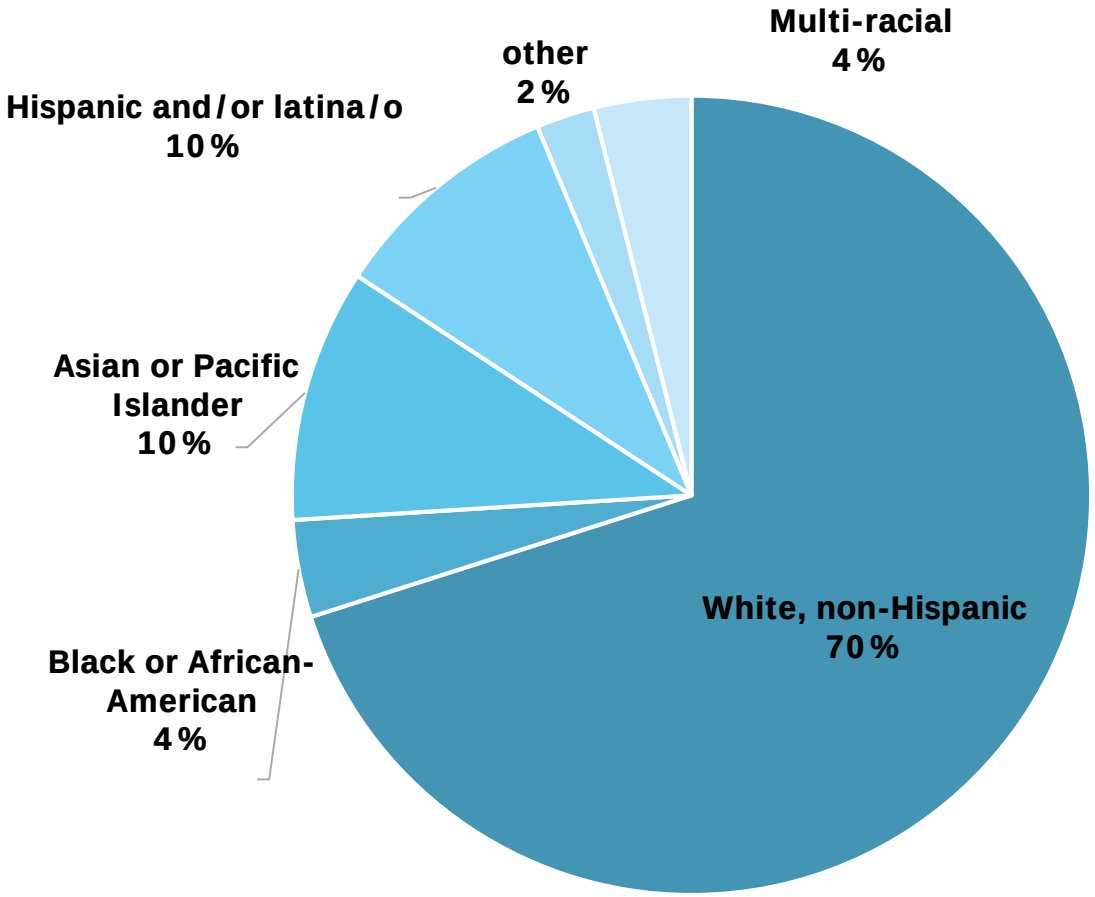
- 277 individuals
- 26 clips rating each, some on riding with children
- 7,166 total ratings



Who took the survey?

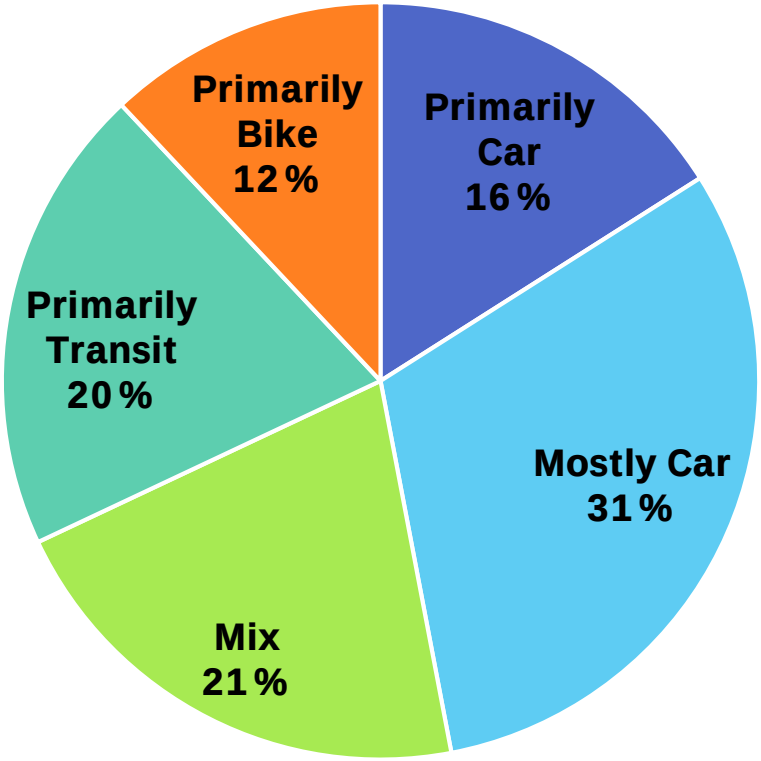




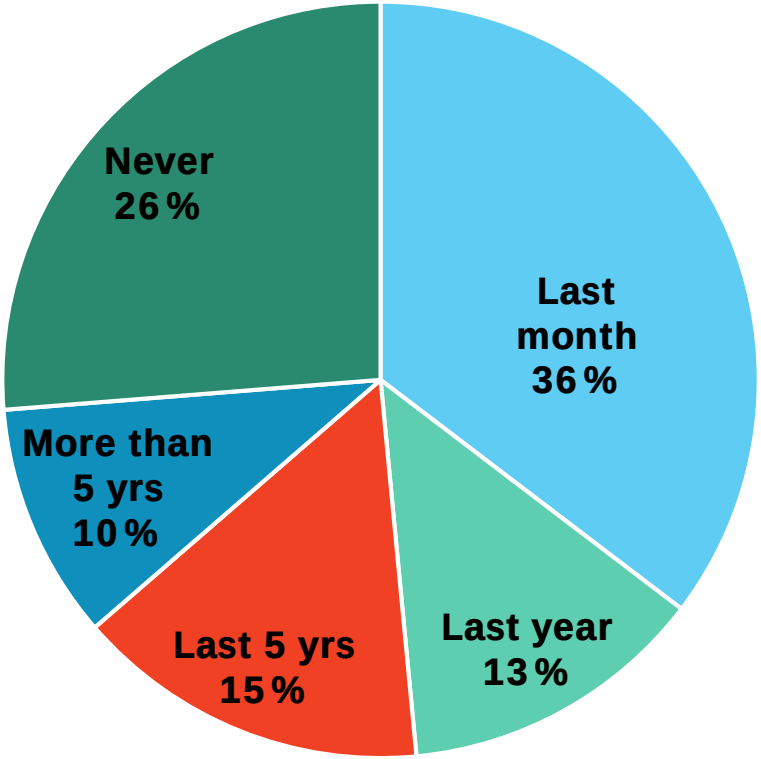


Who took the survey?

90% have driver's license
58% had a working bicycle
45% had a transit pass
57% had a car or truck



Travel behavior categories



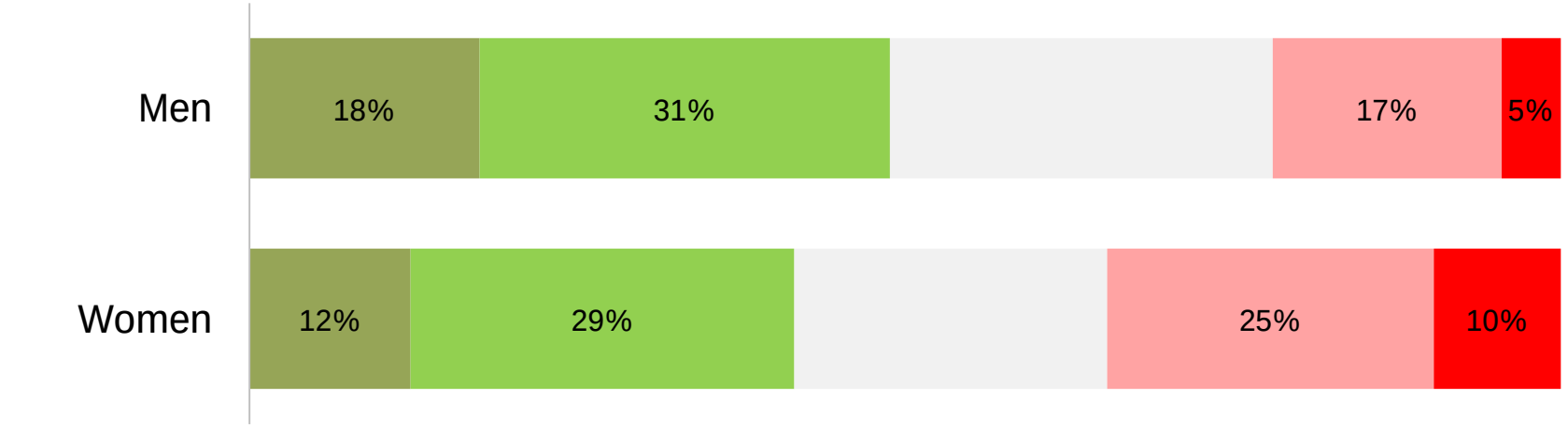
Most recent biking for transportation

Issues to consider with sample

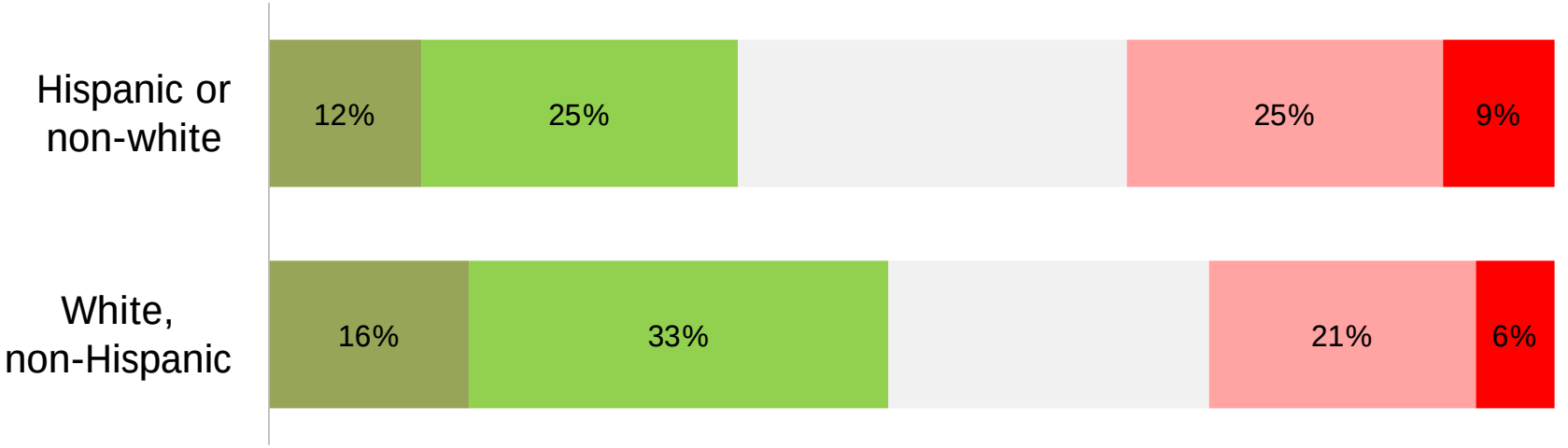
- Not random sample, self-selection bias
- Higher educational attainment than US as a whole
  - In survey 31% had less than bachelors, compared to 68% nationally
- Less likely to have kids in household than US as a whole
  - In survey 16% compared to 29% nationally
- Differences between location and sample demographics
  - Older and less racially diverse in some locations

Survey Results

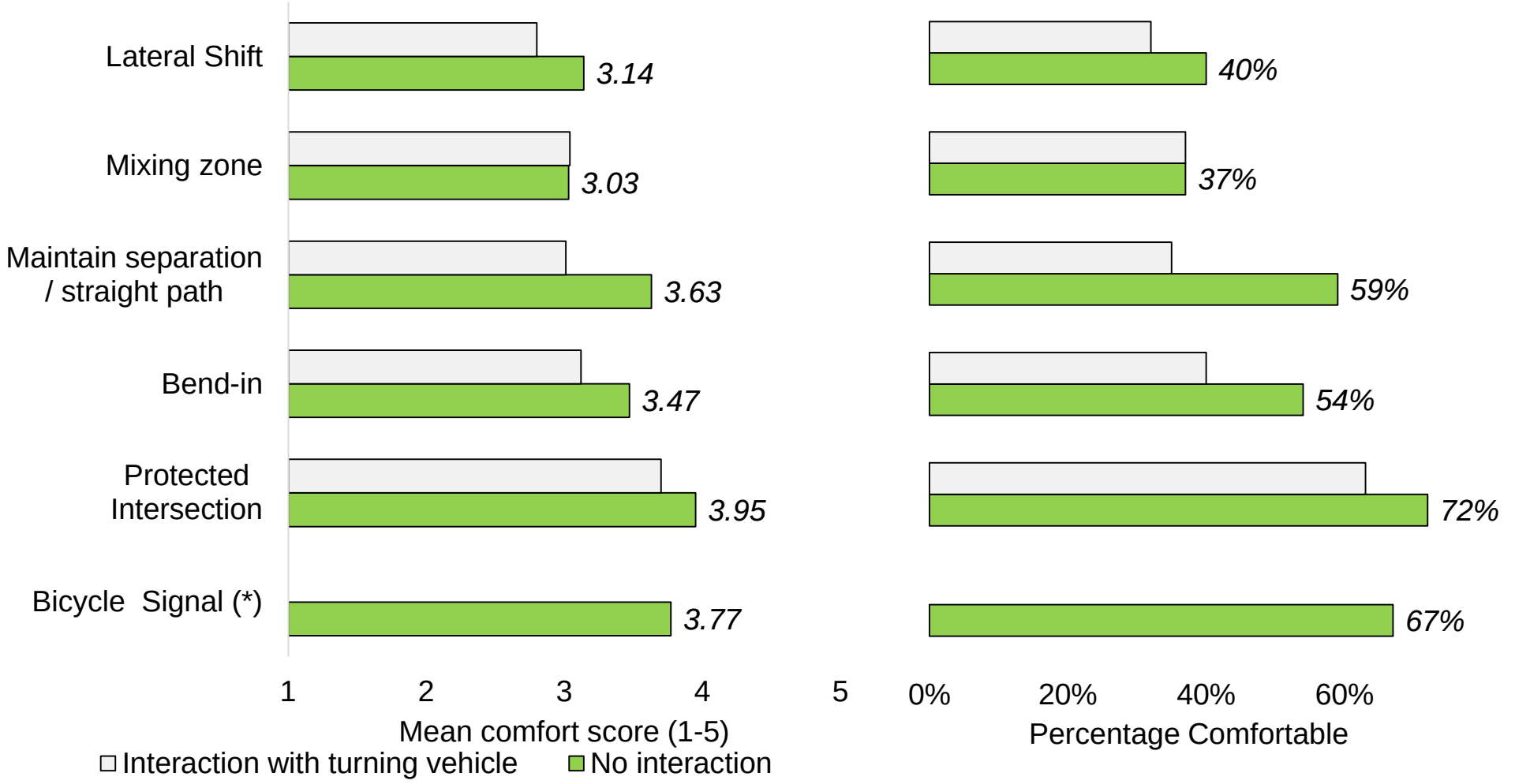
COMFORT BY GENDER IDENTITY



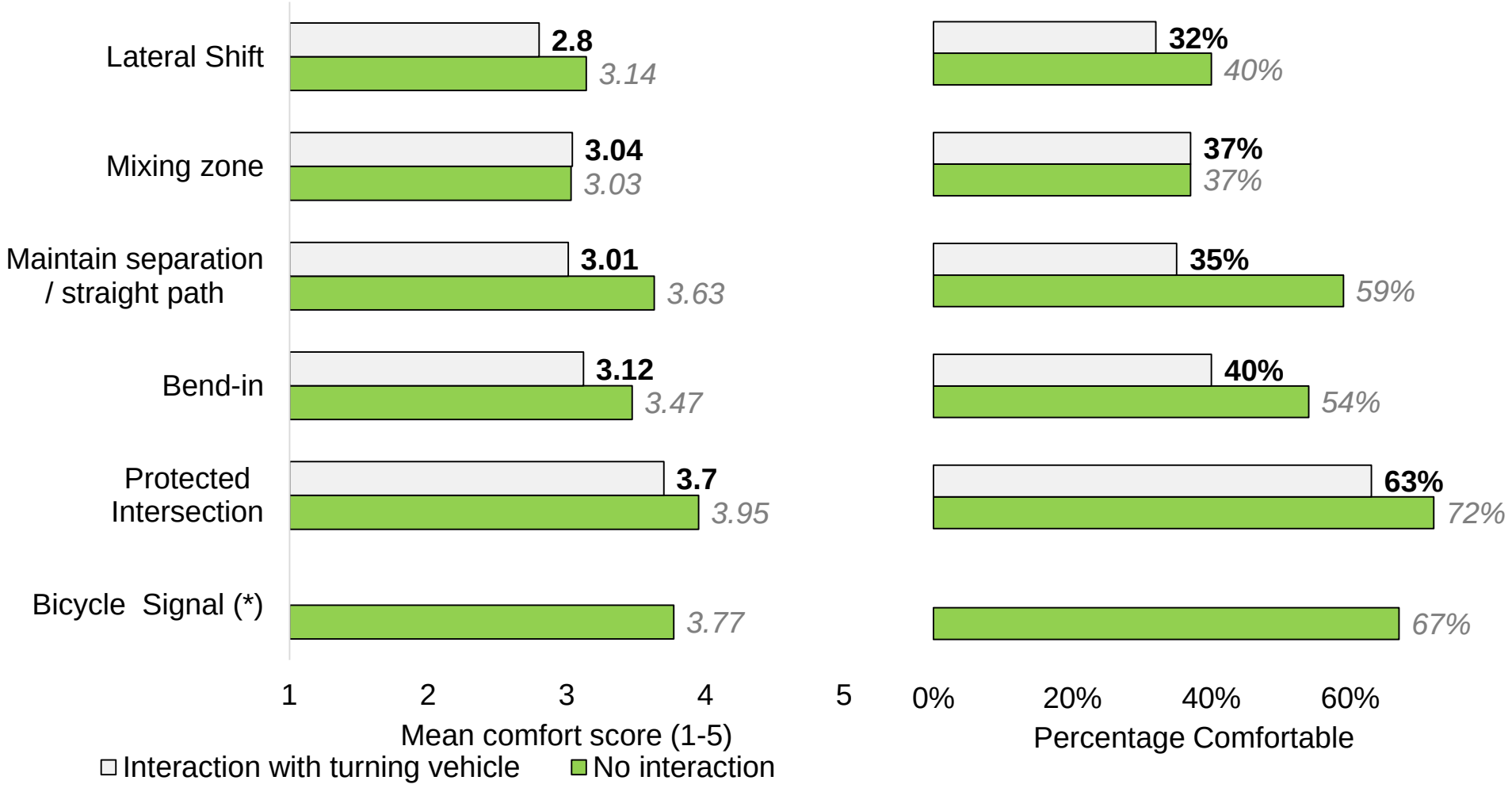
COMFORT BY RACE/ETHNICITY



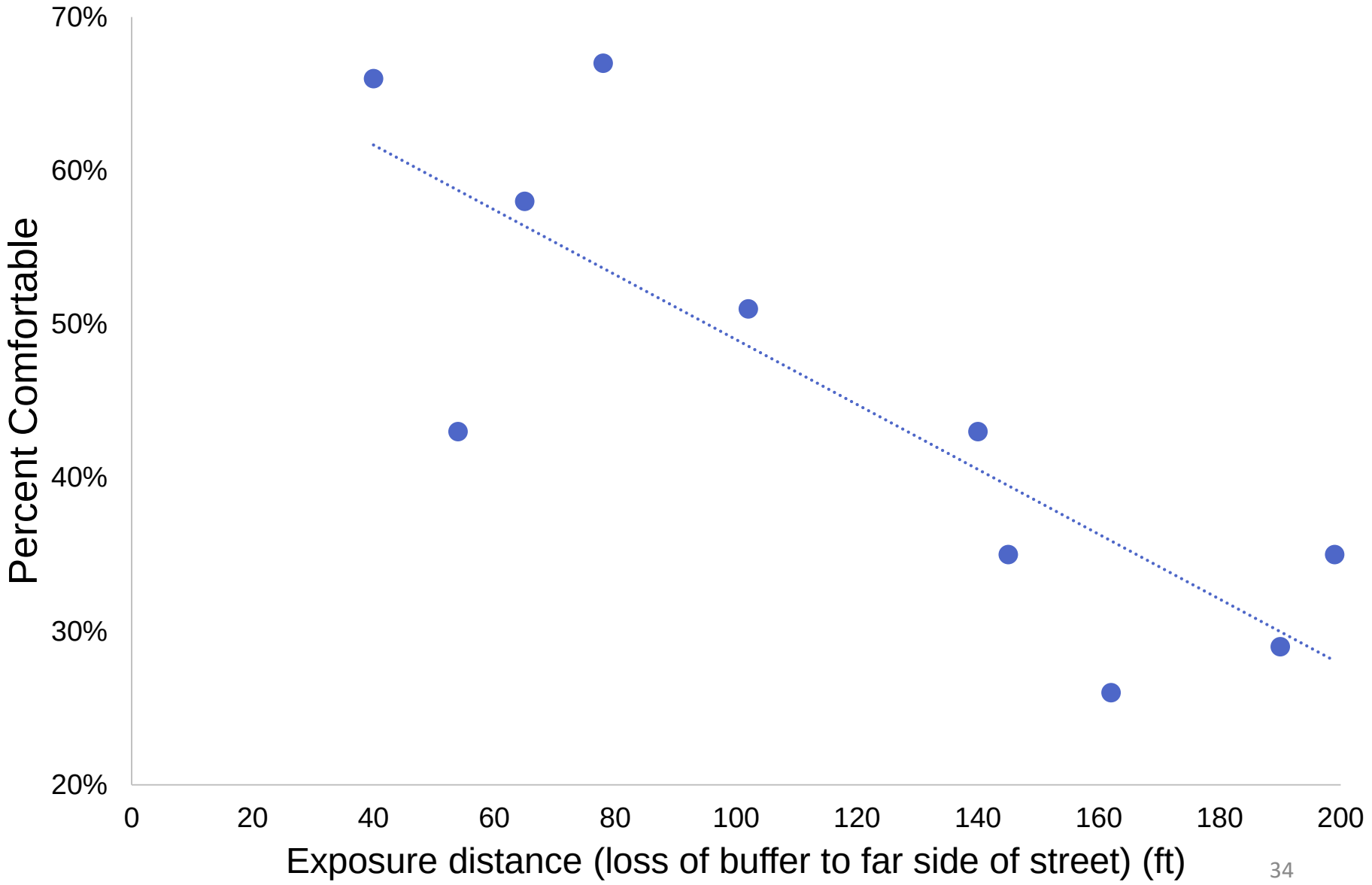
Mean comfort score with and without turning interactions



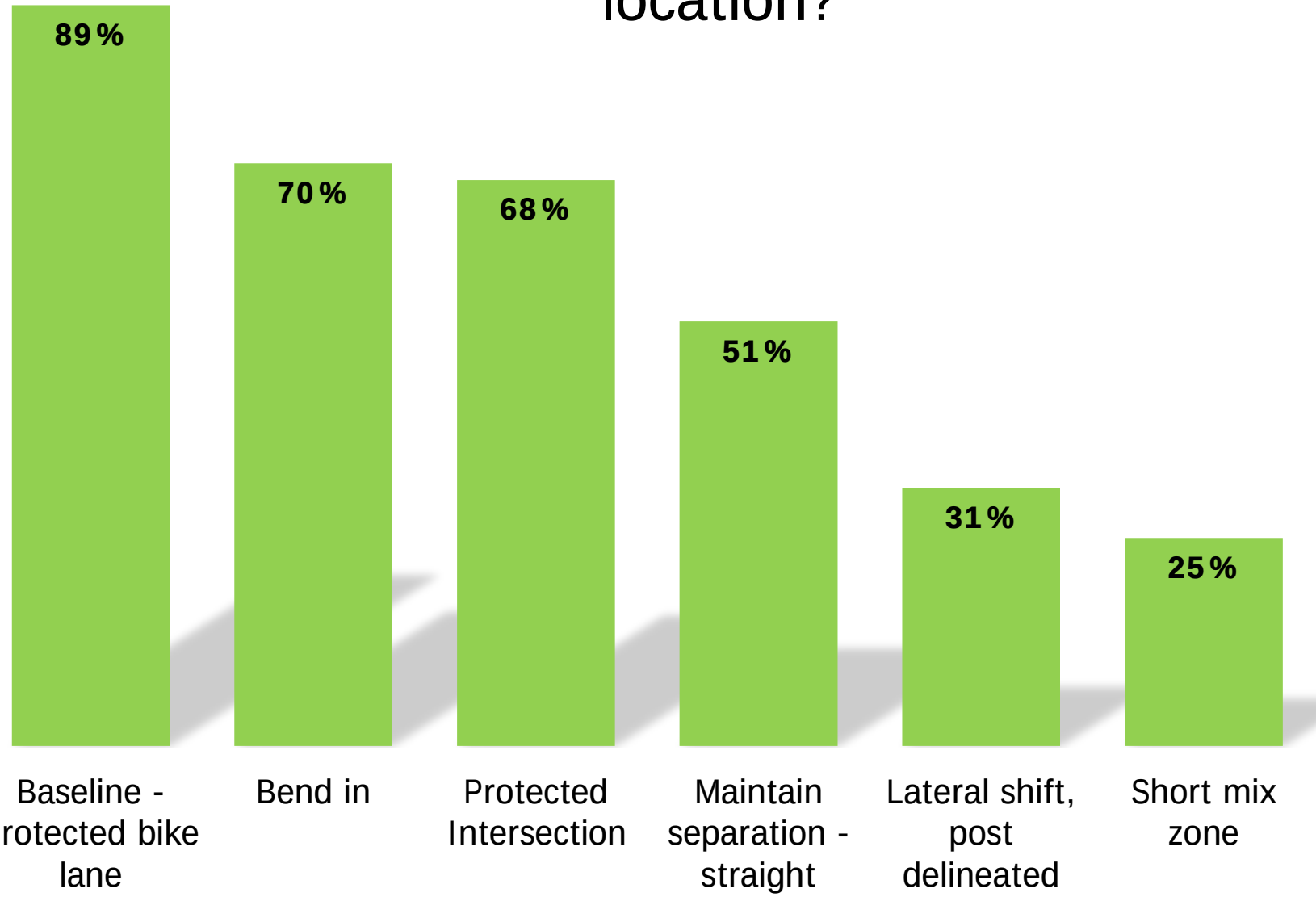
Mean comfort score with and without turning interactions



Percent comfortable by exposure distance



Would ride with a 10 year old in this location?



Would you prefer to ride through intersection A or B on a bicycle?

Of those who chose A, reasons include*:

- Preferred the yield sign/markings (19%)
- Not having to cross a car lane (18%)
- Being able to stay to the right (10%)

Of those who chose B, reasons include*:

- Liking the separation from vehicles (35%)
- Clear lane marking (31%)
- Like the green color (21%)

Would you prefer to ride through intersection C or D on a bicycle?

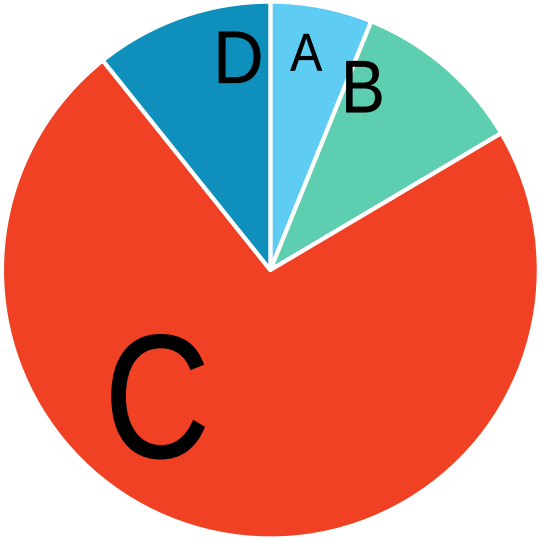
Of those who chose C, reasons include*:

- Protection and separation from vehicles (43%)
- Improved visibility and turning angle (34%)
- Clear markings (17%)
- Slows down drivers, time to react (13%)

Of those who chose D, reasons include*:

- Less confusing design (34%)
- Better visibility and alertness (16%)

Now, compare your preference from A/B to your preference from C/D. Which would you prefer to ride through on a bicycle?



A (Mixing zone design): 6%

B (Lateral shift design): 10%

C (Protected intersection design): 73%

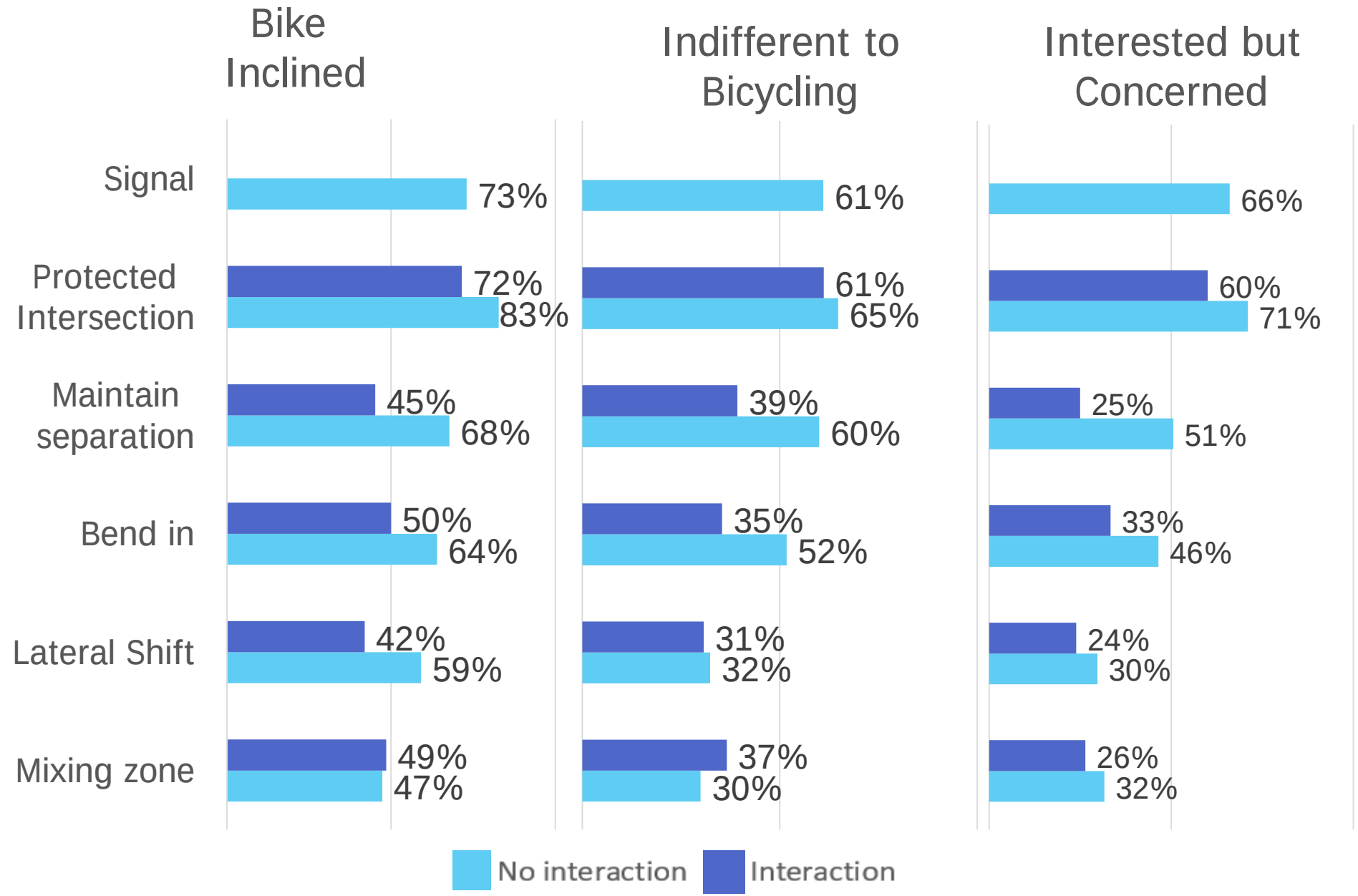
D (Bend-in design) 11%

Cluster Groupings
Exploring “types of cyclists”

K-Means Cluster Analysis, based on attitudes and perceptions toward bicycling

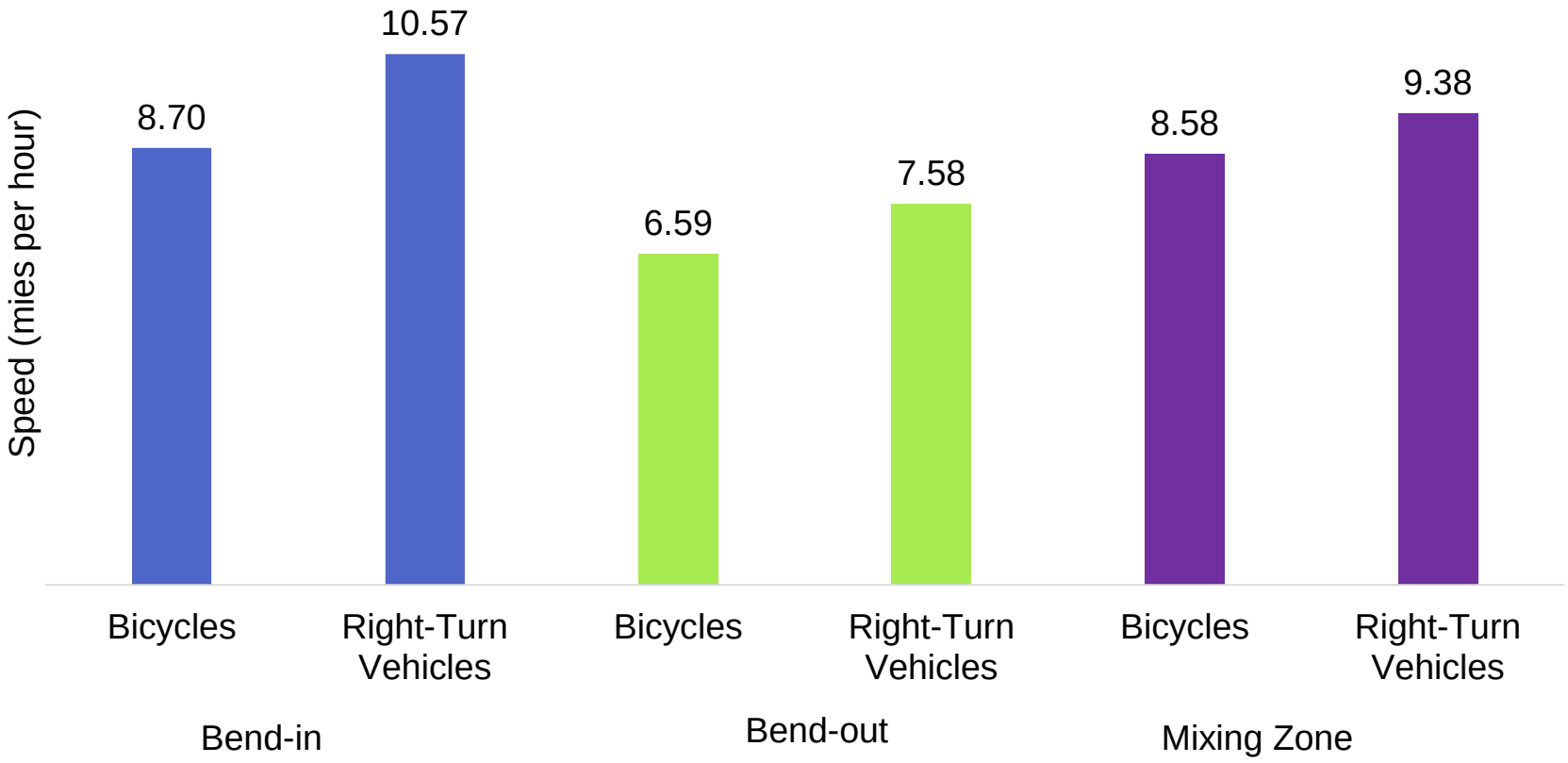
“Bike Inclined”	“Interested but Concerned”	“Indifferent to Bicycling”
• Feel that destinations were within bikeable distances • Not deterred by traffic • Saw people like them riding in their neighborhoods • Most likely to bike for transport	• Interested in biking more • Traffic keeps them from riding more • More likely to be female	• Less interested in bicycling • Don’t view destinations as bikeable • Don’t see people like themselves riding in their neighborhood. • Least likely to have ridden a bike for transport or have a transit pass • Most likely to take most trips by car.

Percentage Comfortable by Design Type

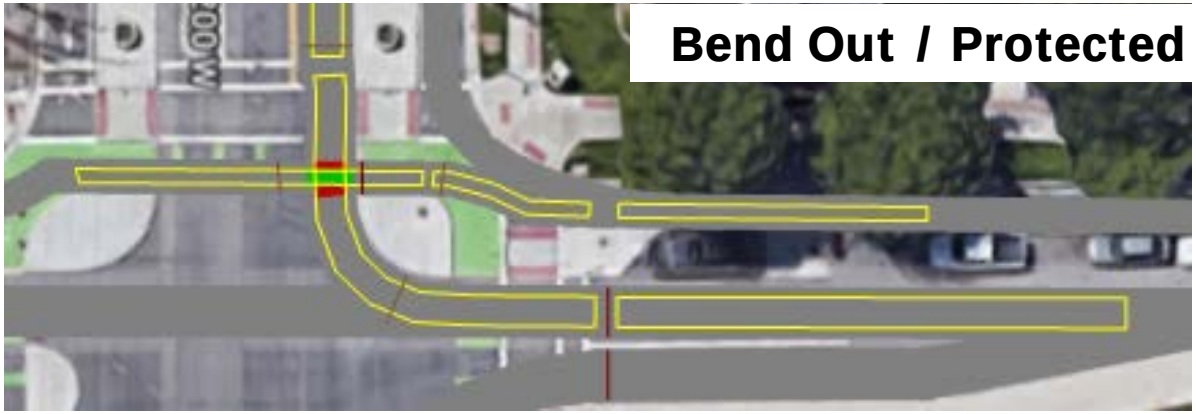


Simulation Modeling

Observed Turning Speeds (mph)



Microsimulation

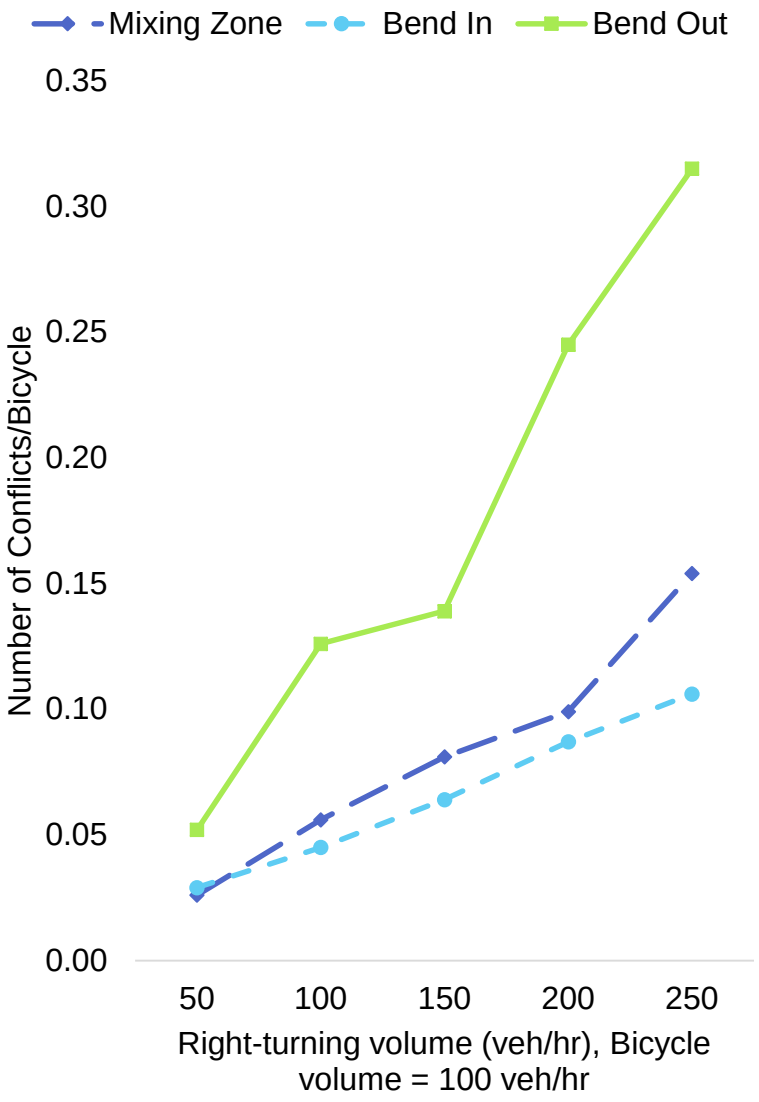


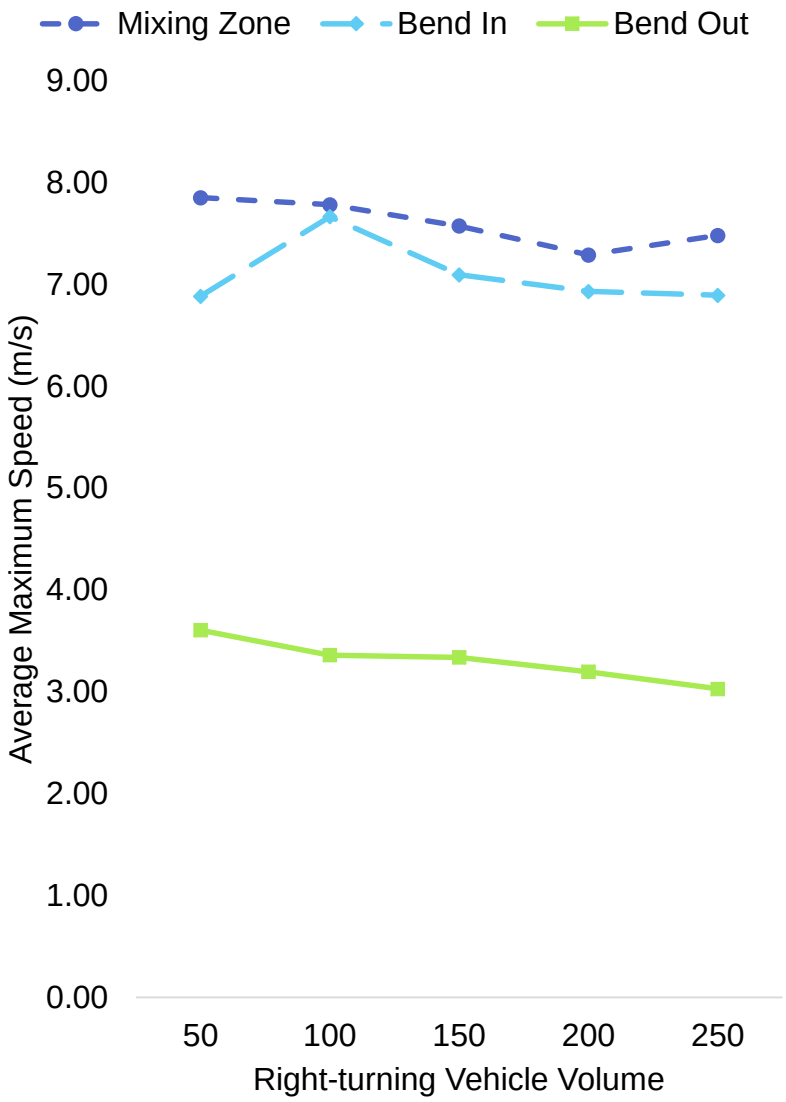
Right-turning volume (veh/hr)	Bicycle volume (veh/hr)					
	25	50	75	100	150	200
50						
100						
150						
200						
250						

- 10 calibrated runs for each volume combination.
- Challenges with yielding/priority interactions of bicycles and vehicles.
- Signal timing not varied.
- “Conflicts” extracted using FHWA’s SSAM tool from simulated trajectories.

Number of simulated conflicts per hour (mixing zone design)

Right-turning volume (veh/hr)	Bicycle volume (veh/hr)					
	25	50	75	100	150	200
50	0.3	1	2.2	2.6	3	4.9
100	1.5	3.1	5.4	5.6	8.3	13.9
150	3.1	3.9	6.8	8.1	12.4	16.4
200	3.2	5.8	9.2	9.9	15.9	24.8
250	2.3	7.3	10.7	15.4	20.8	32.5


Mixing Zone
Bend In
Bend Out
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Number of Conflicts/Bicycle
50
100
150
200
250
Right-turning volume (veh/hr), Bicycle volume = 100 veh/hr


Mixing Zone
Bend In
Bend Out
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Average Maximum Speed (m/s)
50
100
150
200
250
Right-turning Vehicle Volume

Contextual Guidance

Weighted Comfort Scores

Comfort Scores, by typology

Estimated Interactions, Bicycle Volume = b

C_{TV} = No vehicle interaction (turn visible) * b-S= Number of bicycles with no vehicle interaction

C_N = With vehicle interaction * S= Number of bicycles with vehicle interaction

$$CS_{t,b} = \frac{(S * C_N) + (b - S) * C_{TV}}{b}$$

Percent Comfortable, Interested but Concerned

Percent Comfortable		Mixing zone	Lateral Shift	Bend in	Maintain separation	Signal	Protected Int
Turn visible		32%	30%	46%	51%	65%	71%
Interaction		26%	24%	33%	25%		60%
By right-turning volumes	50	32%	30%	45%	50%	65%	70%
	100	32%	30%	45%	49%	65%	70%
	150	31%	29%	45%	49%	65%	69%
	200	31%	29%	44%	48%	65%	68%
	250	31%	29%	44%	48%	65%	67%

Some Limitations

- Research did not study the safety of design options (either in terms of reported crashes or other surrogate measures).
- We were not able to differentiate the aspects of the designs in determining the mean comfort scores (such as the length of the mix-merge length or the offsets for the bend in or bend outs).
- Based context of designs in videos.
- Microsimulation not yet completely validated as tool to replicate reality for bicycle-vehicle interactions. Estimated conflicts should not be extended beyond their purpose in this research.

Conclusions

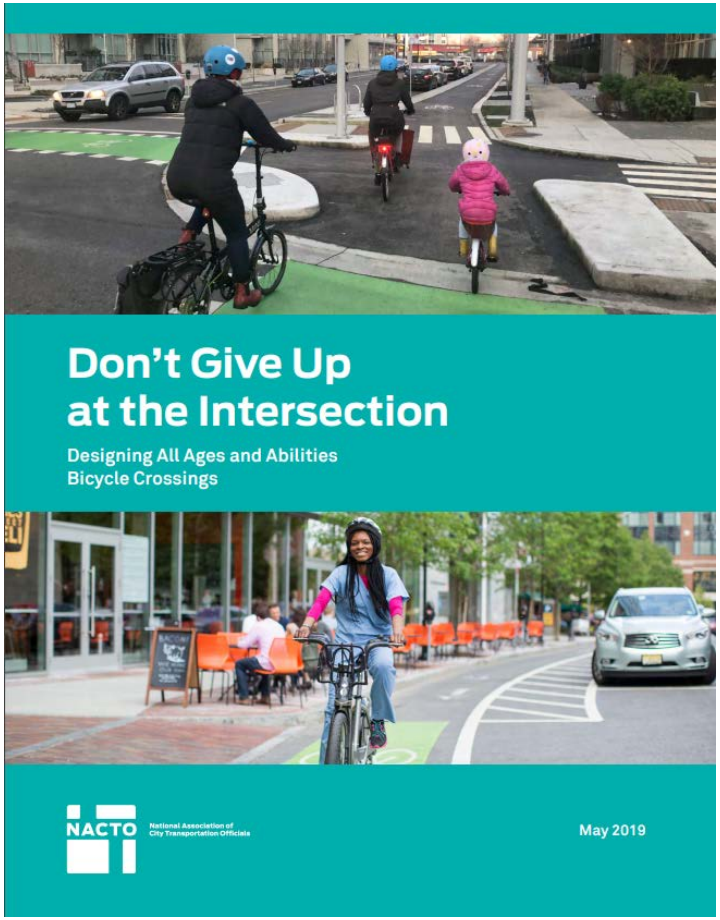
Conclusions (1)

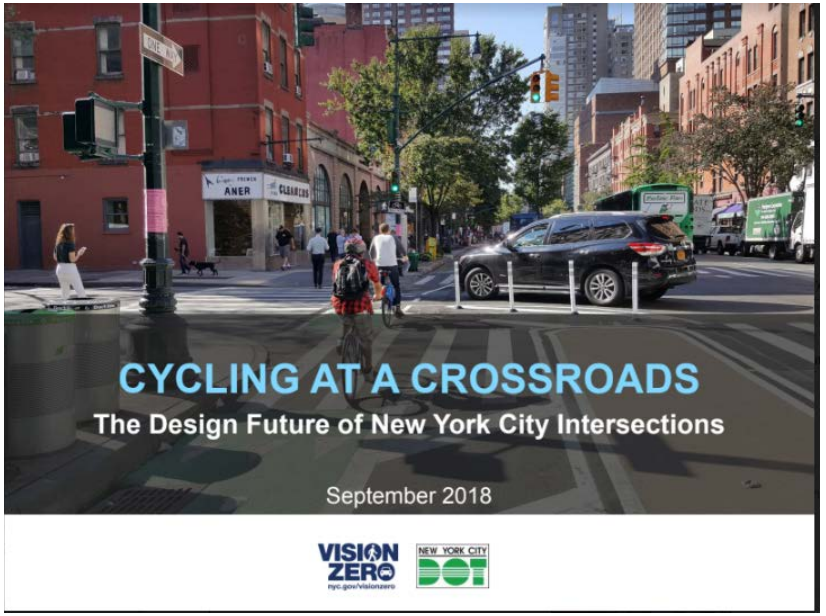
- Separation matters:
  - Protected intersections and bike signals were found to provide the best expected rider comfort.
  - Designs that keep a separate bike lane (bend-in, straight-path) were rated as comfortable by more than half of all respondents but were sensitive to the presence of turning vehicles.
  - Designs that move bicyclists and motor vehicles into shared space (mixing zones or lateral shifts) were viewed as least comfortable.
- Exposure distance is a significant predictor of comfort. Shortening exposure distance is a good design objective.

Conclusions (2)

- "Interested but Concerned"
  - As found in past research finding, this group tends to be the most responsive to changes in the design environments.
  - Less than 30% of would feel comfortable with any form of mixing before the intersection.
  - However, about 67% would feel comfortable at a bike signal and protected intersection.
- "Riding with children"
  - Responses provide valuable insights but should be interpreted with caution as they are each based on a single video clip, without any interaction with a turning vehicle.

Other resources





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Project Team

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